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Title of the thesis: ***A Macroscopic Physical Model for Lightning Return Stroke***

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Abstract

In the design of most of the modern systems, lightning threat needs to be considered at the design phase itself. This demands a suitable model and owing to associated complexity, only simplified modeling have been attempted. As a consequence, it does not provide adequate insight into the phenomena. Considering these, a more realistic time-domain electromagnetic model for the return stroke current evolution has been developed by incorporating the following underlying physical processes: (i) excitation formed by the electric field due to charge distribution along the channel, cloud and that induced on ground, (ii) the transient enhancement of series conductance at the bridging regime, which initiates the return stroke, (iii) the non-linear variation of channel conductance along with (iv) the associated dynamic Electromagnetic Fields (EMFs) that supports the current evolution.

The intended modeling begins from the instant of bridging and the pre-return stroke charge distribution along the channel is calculated using Charge Simulation Method (CSM). For the calculation of dynamic EMFs, the thin wire Time Domain Electric Field Integral Equation (TD-EFIE) is employed The transient enhancement of conductance at the bridging/streamer region is emulated using Toepler's spark law while that along the matured section of the channel is described by first order arc model. The macroscopic physical model developed depicts most of the salient features of current evolution and resulting remote electromagnetic fields in a self-consistent manner. The work is not limited by the simplifications adopted for the channel geometry.

The strength of the model was exploited for investigating a couple of practically important questions, one of which had divided opinion in the literature. Firstly, analysis showed that the "secondary" current waves generated by successive reflection within struck TGO and that fed by branches do not get reflected at the main wavefront. It is shown that the dynamic spatial resistance profile of the channel at the main wavefront is primarily responsible for this behavior. Secondly, it is shown that the abrupt change in radii at TGO-channel junction is mainly responsible for reflection at the junction.

In summary, a novel time-domain macroscopic physical model for the first return stroke of a downward cloud-to-ground lightning has been successfully developed, which is capable of providing much deeper insight into the complex phenomena.